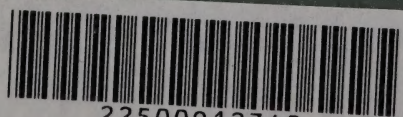


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GENERAL EXERCISE

By THOMAS A. STOREY, A.M., M.D., PH.D.

FOR obvious logical reasons, I have arranged the topical discussion of General Exercise in this chapter as follows: First, the Physiology of Exercise; second, The Prophylactic and Therapeutic Action of Exercise; third, The Untoward Effects of Exercise; fourth, Indications for Exercise; fifth, Contraindications; sixth, The Administration of Exercise; seventh, The Varieties of Exercise at the Disposal of the Practitioner; eighth, The General Application of Exercise.

Physiology of Exercise.—The rational prescription of exercise must rest upon an intelligent knowledge of the more important physiological activities that are directly and indirectly affected by the contraction of the skeletal muscles. The following outline of these more important physiological activities is presented in order to bring out the rationale of the later discussion. The scope of this chapter eliminates any consideration of minor physiological details and limits the presentation to a brief outline of the main relevant facts.

The contracting muscle has a mechanical squeezing, pumping influence upon the vascular tissues with which it comes into pressure contact. This influence serves to accelerate the lymph and venous circulation during exercise. The pressure of the contracting muscles also stimulates the local afferent nerve endings initiating vasomotor reflexes which lead to local vascular dilatation. In these ways the contracting muscle is given an increased blood supply and an increased venous and lymphatic drainage. In addition, the contraction of voluntary muscle is accomplished at the expense of some or all of the various chemical constituents of the neuromuscular mechanisms involved, *i. e.*, the neuron and the striated muscle fiber. In the muscle fiber these chemical reactions result in the diminution of glycogen and in the production of such wastes as carbon dioxide, sarcolactic acid, acid potassium phosphate, and creatin. In the nerve cell the products of activity are less well known, but it has been established that the physiological activity of nerve centres is accompanied by the production of acid wastes. Under the extreme conditions of experimental fatigue in the laboratory it has been shown by the microscope that muscle fiber and nerve cells undergo extraordinary change in their staining reactions. Even the nerve fiber under tests for fatigue displays an altered reaction to histological stains.

It is evident, then, that voluntary muscular contraction is accompanied by chemical losses in the nerve cell and muscle fiber. The waste products of these chemical reactions are emptied into the lymph and blood streams surrounding these tissues, and must be reckoned with

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Treatment. Leas Fibiger, 1910.*

qualitatively and quantitatively in estimating the probable effects of exercise in any given case. The chemical losses sustained by the muscle fiber and the neuron are replaced by supplies furnished these organs from the blood and lymph. These supplies are the food substances absorbed from the intestinal canal and from the alveolar spaces of the lungs. The ultimate source of these supplies (tissue foods) are the proteids, fats, carbohydrates, salts, and water taken in by the way of the alimentary canal, and the oxygen taken in by the way of the respiratory tract. It is evident, then, that exercise involves a heightened metabolism in muscle and neuron, producing an increase in katabolic waste and anabolic demand. This necessarily increases the excretory activity of the tissue cells filling the lymph and the blood with waste products and bringing those products into intimate association through the blood stream with all the cells of the body, giving opportunity for hormone action, and finally throwing a greater burden upon the excretory organs, chiefly the kidneys, the lungs, and the skin.

It is apparent, then, that for our purposes we must consider the physiology of exercise from the standpoint of the local mechanical effects of muscular contraction and from the standpoint of katabolism, hormone action, excretion, anabolism, anatomical structure, and organic function.

1. **The Local Mechanical Effects of Muscular Contraction.**—The alternation of contraction and relaxation of muscle during exercise serves to press the fluid contents out of the smaller lymph spaces in the muscle tissue and to squeeze the lymphatic and venous streams in the direction of least resistance. Because of the valvular arrangements in these systems this pressure is afferent, and results in accelerating the lymphatic and blood circulation within and about the muscle mass. This assists in the circulatory removal of the chemical products of tissue activity.

In addition the local intra- and extramuscular movements excite the sensory nerve endings within the muscle substance and in the adjacent tissues, so that various nervous reflexes are established. These reflexes probably have much to do with the remarkable refinements of neuromuscular coördination which are so commonplace to us. For our purpose the important fact in this connection is that these reflexes are also largely vasomotor in character and have much to do with the increase in blood supply to the contracting muscles and with the general increase in peripheral circulation present during and for a short time following general physical exercise.

2. **The Influence of Exercise upon Katabolism.**—All organic activity is accomplished at the chemical expense of the tissues involved. Physical exercise is fundamentally a function of the motor neuron and the striated muscle fiber, but it is necessarily inseparably associated with the normal functional activity of various connective-tissue sheaths, aponeuroses, tendons, ligaments, bones, joints, lymphatic spaces, blood capillaries, lymphatic and blood-vascular systems, the heart and lungs, the hemapoietic organs, various afferent and efferent nerve tracts and systems, the spinal and cranial nerve centres, the special senses, and the various glandular structures of the alimentary tract. In fact, practically

all the organs of the body may, under the influence of physical exercise, be thrown into greater functional activity, and therefore be called upon for an increased expenditure of chemical resource. Even though the increased loss in any given tissue cell may be infinitesimal, the summated increase from some millions of tissue cells, dependent upon the extent of the physical exercise, may amount to a great deal compared to the normal loss.

The chemical reactions which take place during the functional activity of the tissue cell, and on which the nature of that activity depends, are chemical reactions within the substance of the cell. These reactions form products which are eliminated from the cell as wastes. As a result of this action the cell loses a part of the material which it has constructed, and, in addition, suffers more or less structural wear and tear. This destructive process—katabolism—throws various waste products into the lymph and blood streams.

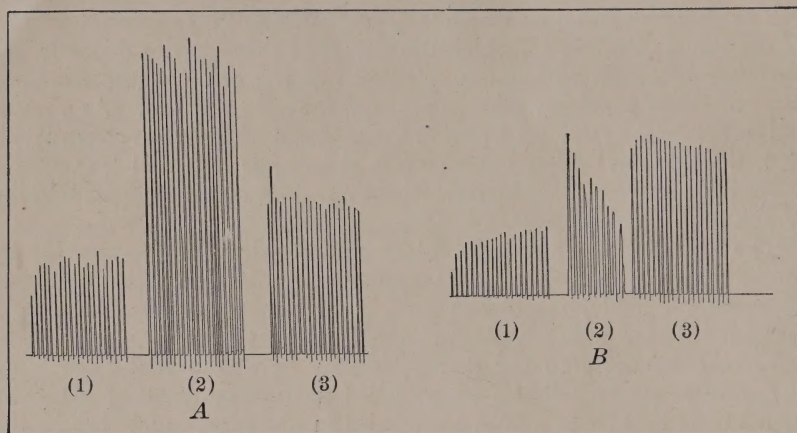
The contraction of the voluntary muscle fiber is accompanied by an increased evolution of heat and the elimination from the fiber of carbon dioxide, sarcolactic acid, acid potassium phosphate, and creatin. These substances are called "fatigue substances." Without going farther into the details, it may be stated that each functioning tissue contributes its so-called wastes as a result of katabolic action, and that these wastes are carried in one form or another by the blood all over the body. Each tissue is bathed by a solution of these waste products in blood. Some of these products enter into chemical associations in the blood, which may alter their possible toxicity; carbon dioxide is largely eliminated by the lungs before it reaches the arterial stream. But the fact remains that the chemical wastes or fatigue products of voluntary muscular contraction and the increase of chemical waste from other tissues affected by physical exercise must have a more or less stimulating, irritating, or depressing influence, as the case may be, upon the general tissues and organs of the body, particularly upon the cells of the central nervous system, before they are finally excreted from the body.

3. The Hormone Action of the Katabolic Products of Physical Exercise.—These fatigue or waste products come into contact first with tissues of the voluntary muscles themselves.

Lee's investigations show that "the physiological action on skeletal muscle of each of the commonly recognized fatigue substances, namely, carbon dioxide, paralactic acid, and monopotassium phosphate, is of two opposite modes, the appearance of the one or the other mode being dependent upon the quality of the substance that is present and the duration of its activity. If present in small quantity, or moderate quantity, for a brief time each substance causes an augmentation of activity of the muscle, which is characterized by an increase in irritability and working power. If present in moderate or large quantity, or in smaller quantity, for a longer time, each substance causes a depression of activity or fatigue of the muscle, which is characterized by a decrease in irritability and working power."

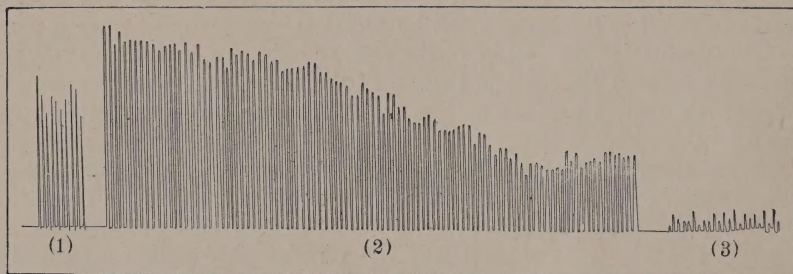
In my own investigations I have shown that "human voluntary muscle is made more irritable by successive excitations (electrical); that the irritability of human voluntary muscle is immediately very greatly increased by a moderate amount of work (Fig. 2); and that it is very greatly decreased by a fatiguing amount of work¹ (Fig. 3).

FIG. 2



The curves read from left to right. *A.* (1) Contractions of the human abductor indicis muscle upon electrical stimulation, against very slight resistance; (2) voluntary contractions against considerably increased resistance; (3) conditions as in (1). *B.* Conditions as in Series *A*, except that the resistance to voluntary contraction was very much greater.

FIG. 3



(1) Electrical stimulation, very slight resistance; (2) voluntary contraction against considerably increased resistance; (3) conditions as in (1).

These waste products have a further local influence upon the arterioles of the contracting muscle. The local vasodilatation is largely a vasomotor reflex, but it is also probably brought about through the medium of a vasodilator hormone given off by the working muscle. This influence assists in securing an increase in the blood supply of the contracting muscles.

¹ Storey, American Journal of Physiology, 1903, ix, 52.

The lymph and blood streams carry these waste products in solution, or in some form of chemical association, away from their places of origin and distribute them in the blood stream to all the tissues. Our present knowledge of the susceptibility and response of the fixed and circulating tissue cells of the body to the stimulating action of circulating irritants of various sorts leads us to expect that these various circulating acid wastes of voluntary muscular contraction must have a more or less important influence upon the functional activity of all the organs of the body. This is the simplest explanation of the various more remote influences of exercise. This is particularly true in the relation between muscular work and the functional activity of the central nervous system. A number of central and spinal centres are stimulated to greater activity through the products of muscular work. As soon as the tension of carbon dioxide in the pulmonary alveoli and in the pulmonary veins exceeds the normal, this chemical waste becomes a stimulant of the respiratory centre, causing a more rapid respiratory rhythm, and therefore a more rapid removal of carbon dioxide from the alveoli of the lungs. When these katabolic products are carried to the central nervous system in sufficient amount they apparently stimulate the cardiac centres and thus assist in accelerating the heart beat.

In the same general way the nerve centres controlling the action of the sweat glands are stimulated to greater activity because of the action of these centres of chemical wastes given off by the working muscle and brought in contact with the nerve centres by the blood.

The increase in blood pressure accompanying exercise is another phenomenon which is at least partially due to the action of these products on the vasomotor centres.

It is possible, too, that the general growth stimulus that follows systematic exercise in younger persons may be due to an anabolic stimulus from some hormone given off during muscular contraction.

Experiments which I performed in the physiological laboratory of Stanford University, in 1899, show that moderate exercise of the larger muscle groups is accompanied by an increase in the irritability of the motor centres of the brain. After such exercise smaller muscle groups—in this case the deep flexors of the forearm—previously voluntarily fatigued, could be voluntarily stimulated to do a normal quantity of work in spite of their diminished irritability. This effect was in all probability a result of the stimulating influence of the chemical products of muscular activity carried to the cerebral cortex and there brought in contact with the nerve cells of the motor centres.

So far we have been considering the general stimulating influences of these waste products. We noted in considering the influence of these chemicals upon the muscle fiber that a depressing influence followed their excessive or prolonged production. The same law operates in the general influence of these products. A depressing or fatiguing influence accompanies the rapid excessive production of these chemical wastes. And, too, it may be stated that any prolonged production in excess of the ability of the organism to neutralize or eliminate those toxic products

will eventuate in respiratory, cardiac, and general fatigue, functional depression, febrile reaction, and, in extreme cases, in organic injury.

All of our various theories, offered in explanation of sleep, include prominently the depressing effects on the higher nerve centres by the acid wastes of tissue metabolism attendant upon the day's work.

4. The Influence of Exercise upon Excretion.—The elimination of these various waste products from the blood is the function of the several excretory organs, chiefly the lungs, skin, and kidneys.

The lungs and skin excrete the carbon dioxide produced by the low metabolism of the tissues at rest or by the high katabolism of the tissues in activity. In each case the increase in the amount of the excretion, and therefore the increase in the amount of work performed by the excretory organs, is directly proportional to the quantity of carbon dioxide produced by the working tissues.

The elimination of water by way of the lungs and skin, like the elimination of carbon dioxide by those organs, is relatively proportional to the amount of physical exercise taken by the individual. There is, concomitantly, a reduction in the amount of water eliminated by the kidneys and the mucous membrane of the alimentary tract. Under these circumstances we find a drier mouth, drier fecal discharges, and a more concentrated urine, unless the increased elimination of water is compensated by a proportional increase in the ingestion of liquids.

Most of the remaining wastes are excreted by the kidneys. The solid wastes eliminated by the skin may be neglected for our purposes. In general we find that the tissues waste, and particularly the wastes from the muscular tissues, eliminated by the kidneys, are ammonia, the endogenous purin bases, and creatin. The ammonia formed by hydrolytic cleavage of the protein molecule in the tissues is converted into urea by the liver and excreted by the kidney as urea. The uric acid and other endogenous purin bases excreted in the urine are derived mainly from the dissimilation or katabolism of the voluntary muscles. The amount of uric acid in the urine is increased within a few hours after exercise.

Creatin is a normal product of the metabolism of skeletal muscle. It appears in the urine as creatinin. Some authorities state that the elimination of creatin is increased by muscular exercise. Others state that there is no such relationship.

In addition to these eliminations by way of the kidney, I have found uniformly that the urine contains albumin after severe physical exercise. This has been the finding in all the investigations that have come under my observation. In some cases the investigation has included a microscopic examination of the urinary sediment, and it has not been infrequently found that severe physical exercise has caused the appearance of acetone, blood cells, and casts in urine which ordinarily contained neither acetone, albumin, nor abnormal sediment.

5. The Influence of Exercise upon Anabolism.—The loss of chemical material in the tissue cells, whatever and wherever those cells may be, is replaced from the food content—the chemical supply—of the blood.

These cells rebuild themselves and restore their peculiar losses from this common source—the blood. The muscle cells not only repair themselves structurally, but they also store up glycogen for future contractile activity. The neuron not only repairs any losses from wear and tear in its own structure, but also stores up its chromophile substance for further functional activity in the elaboration of its nerve impulse. And so each tissue cell that has participated more or less directly and more or less extensively in the functional activity of the motor neurons and the striated fibers concerned in physical exercise, or that has been brought directly or indirectly into chemical coördination through the influence of the circulating chemical products of that activity repairs its structural losses and its functional losses from the same source; that is, the blood, and the blood, of course, derives its food supply through the digestive and respiratory tracts. The extent of this building-up and repairing process, and the extent of the demands upon the food supply of the blood, depends upon the quantity and quality of the physical exercise taken.

It is evident, then, that anabolism, the reconstruction and repair of cellular structure and the manufacture of the various special tissue substances, is more or less profoundly affected by physical exercise.

A wise prescription of exercise, in the absence of such incompatibilities as bad habits of eating, insufficient nourishment, bad habits of excretion, nervous strain, and insufficient rest, and in the absence of pathological contraindications, may, therefore, in the young person promote growth, and in the older person secure an approximately normal weight.

6. The Influence of Exercise on Structure.—It is a well-established fact in physiology that an unused organ does not develop properly; that a period of long disuse leads to atrophy; that regular exercise of an organ leads to its normal development and growth; and that organs that are exercised a great deal are, in most cases, hypertrophied. These structural changes are associated with the anabolic effects of exercise, and are most apparent in the nervous and muscular tissues, in the heart, and in the tendons, ligaments, connective-tissue sheaths, bones, and joints associated with the voluntary musculature.

It seems to be true also that in certain tissues at least exercise not only increases the size of the individual element (muscle fiber, for instance), but also increases the number of the tissue elements present. So that there are more muscle fibers in the regularly exercised muscle and more nerve cells in the regularly exercised motor centre than in those muscles and centres that are not regularly exercised.

The voluntary muscles have another characteristic reaction to exercise. A muscle that is exercised a great deal tends to shorten permanently. This accounts for some of the minor asymmetries that are found in the trained athlete and "strong man," such as uneven height of shoulders, excessive flexion of the elbow at rest, certain types of "round shoulders," and so on. The orthopedic surgeon takes advantage of this characteristic in treating faulty attitudes, chest deformities, scoliosis, flat foot, and other similar conditions.

7. The Influence of Exercise upon Function.—Exercise has a local and a general effect in its relation to the functional activity of the human organism. Locally the exercised muscle, with its increased size and number of individual fibers, develops a greater contractile power. And the governing motor centre sends out stronger and more effective nerve impulses. Depending upon the nature of the exercise, the reaction time, the speed of motion, and the endurance of the neuromuscular mechanism are increased, normal coördination becomes more perfect, and new coördinations may be established. The functional efficiency of the muscle tendon, connective-tissue sheaths, ligaments, bones, and joints is, within physiological limitations, directly increased in proportion to the extent of their participation in exercise.

Associated with its beneficial influence upon general metabolism, physical exercise causes a general increase in the functional efficiency of the organ. The heart develops a greater strength, regularity, and endurance. Circulatory activities are improved. The depth of inspiration is increased. The rhythm of respiration is slowed. The strength, endurance, and coördination of the neuromuscular elements controlling the movements of respiration are improved. The necessary and very intimate coördination between the complex respiratory machine, the complex circulatory machine, and the complex vasomotor machine is brought into more perfect adjustment and efficiency. The heat regulation of the body is improved. Digestion, metabolism, and excretion are improved.

In fact, under the influence of wise habits of physical exercise, other conditions being normal, the human organism approximates its limit of structural and functional efficiency.

The Prophylactic and Therapeutic Effects of Exercise.—The facts presented in the preceding discussion indicate the prophylactic and therapeutic values of physical exercise.

One of the most important factors in preventive medicine is the resistance or immunity of the individual to disease.

“The production of active or potential immunity is a function of some of the fixed and circulating cells of the body. When pathogenic organisms within certain limits of virulence gain access to the tissues they are destroyed or rendered innocuous by one or more of several processes. They may be devoured by phagocytes; they may be killed and dissolved by agents in solution in the tissue juices; they may be imprisoned and walled off locally from the rest of the tissues; and their toxic products may be neutralized or destroyed by soluble antibodies in the tissue fluids. These several defensive activities are carried on directly by the tissue cells or indirectly by the products of the vital activities of those cells. On the cells of the body depends the exhibition of the phenomena of immunity.

“The degree of immunity produced is related directly to the health of the cell. An impoverished, poorly nourished, unhealthy cell will not react to the same extent and with the same success as will the normal, healthy, well-nourished cell.

“The health, and therefore the immunity producing power, of the cell

depends upon its nourishment, including food, water, and oxygen; upon its relief from the toxic influence of its own waste products; upon its exercise; upon its opportunities for rest and repair, and upon a reasonable freedom from the direct and indirect influences of pathogenic organisms. These facts have everywhere been forced upon the attention of men who are experimenting with the immunity reactions of the blood. They find healthy blood is necessary for good reactions. Bactericidal phenomena, phagocytosis, bacteriolysis, agglutination, the productions of antitoxins, and the other phenomena of immunity are all more marked in blood taken from healthy animals. It has been found in laboratories everywhere that a reduction in mortality and a more successful experimentation with the vital phenomena of cellular structures in experimental animals accompanies the provision of good and sufficient food, exercise, and careful sanitation. The health and, therefore, the immunity of the whole body depends upon the health of all its constituent parts—on the health of its cells. If the cells are all well nourished, active, and protected from extremes of pathogenic influences, their summated health will be the health of the individual whose body they in combination make. That such a healthy individual is possessed of a certain degree of immunity has been proved empirically and experimentally, and it is equally well established that the possession and conservation of the healthy body depend upon the observance of several simple hygienic procedures. These hygienic procedures are the same as those which I have already stated were essential to the body cells. Furthermore, these procedures must be the fundamental procedures in any wise and well-ordered policy of personal health control.

“The well-planned policy of personal health control teaches men to eat properly, to drink properly, to breathe properly, to take proper care of the excretions and wastes, to exercise wisely, to rest wisely, and to keep reasonably clean with reference to disease-breeding organisms. Such governing principles lead to and conserve human health. Failure to respect any one of these principles will jeopardize the success of the others. No rational scheme should rely upon exercise alone for health, nor upon any other one procedure or habit. One must respect all of these several requisites in order to work under a wise policy of personal health control. The man who regulates his habits of eating and takes no exercise cannot expect health. The man who exercises properly and eats wisely will fail to secure health if his habits of sleep are bad. On the other hand, a reasonable observance of these several simple hygienic laws cannot fail to secure and conserve health for the average individual.

“Such an individual will be possessed of millions of active, healthy cellular structures working for his protection, constructing for him a defensive armamentarium, and ready on demand to respond with supreme reaction against the invasion of disease.”¹

Therapeutically, we may consider that the general physiological con-

¹ Storey, Proceedings of Section V, International Congress on Tuberculosis Washington, D. C., 1908.

dition of the actively healthy body makes its recovery from infection more easily possible. This is an overlapping of the prophylactic and therapeutic effects of exercise. It is the only way in which it may be said that exercise has a therapeutic mission in the acute stages of febrile diseases. Health of cell and health of body depend, among other things, upon physical exercise. Exercise of the body exercises the cells of the body. Without bodily exercise, the tissue cells cannot be actively healthy. In a well-ordered policy of personal health control, wise habits of exercise do their full and important share in improving the physiological efficiency of the tissue cells of the organism, developing their powers of resistance to disease. In one case this resistance may enable the tissues to destroy the invading bacteria of disease immediately on entry into the tissues. In another case it may enable the tissue to develop its physiological defences successfully but slowly, so that there is an acute disease attack followed by recovery. This is the common experience of the organism in the course of infections from which it recovers. It is only in such a way that physical exercise may be used "therapeutically" in the treatment of infections during their acute stages. This treatment is prophylactic in point of time.

I know of no diseased condition in which exercise is indicated during the acute febrile stages, and there are very few non-febrile diseases in which it is indicated during the acute attack or exacerbation. Our additional therapeutic uses of exercise, then, are limited to applications during recuperation, to treatment of certain chronic non-febrile conditions, and to special prescriptions arranged for general health effects in the presence of more or less seriously disqualifying chronic lesion.

In estimating the therapeutic, prophylactic, and general health effects of exercise, one must take into consideration the following physiological effects of exercise:

(a) An immediate, transient, local increase in the blood supply of the muscle.

(b) An immediate, transient, local increase in the lymphatic and venous drainage of the muscle.

(c) An immediate and transient increase in the heart rate, blood pressure, and rate of respiration.

(d) An immediate and transient increase in the superficial circulation.

(e) A later, more lasting increase in the size, strength, and functional endurance of the exercised muscle.

(f) A later, more lasting decrease in the length of the exercised muscle.

(g) A later, more lasting increase in the size and strength of the tendons, ligaments, sheaths, bones, and joints directly associated in exercise.

(h) A later, more lasting increase in the size and efficiency of the nerve cells in the exercised motor centres.

(i) An improvement and perfection of old neuromuscular coördinations.

(j) The establishment of new neuromuscular coördination with the possibility of developing new paths for the afferent and efferent nerve impulses.

(*k*) An increase in the size, strength, functional endurance, and efficiency of the heart.

(*l*) An improvement in the regulation of the vasomotor balance.

(*m*) An improvement in the blood and lymph circulation.

(*n*) An increase in the strength, endurance, and coördination of the musculature of respiration.

(*o*) An improvement in the depth and rhythm of the thoracic and diaphragmatic movements governing the ventilation of the pulmonary alveoli, and augmenting the speed of the general lymphatic and venous circulation.

(*p*) An improvement in the operation of the heat regulating mechanisms.

(*q*) A perfection of the mutual neuromuscular coördinations associating cardiac, circulatory, pulmonary, and vasomotor activities.

(*r*) An increase in general katabolic activity.

(*s*) An increased circulation of the products of the chemical activities of all the tissues and organs associated directly and indirectly in physical exercise.

(*t*) A larger hormone effect of these products (among them carbon dioxide, acid potassium phosphate, sarcolactic acid, ammonia, creatin, and the endogenous purin bases).

(*u*) An increase in the elimination of carbon dioxide by the lungs; of water and carbon dioxide by the skin; of uric acid and creatin by the urine.

(*v*) A desire for rest after exercise, and a desire for sleep at the end of the day.

(*w*) An improved appetite, better digestion, more food in the blood for the tissues, a greater demand for food by the tissue cells (a benignant circle).

(*x*) An increase in the anabolic activities of all the tissues concerned directly and indirectly in exercise, with, therefore, a general structural and functional benefit.

(*y*) A gain in weight or an increased growth, or both, continuing until the metabolic equilibrium is reëstablished.

(*z*) A perfection of the physiological efficiency of the whole organism, with consequently

(*a*) A better development of the powers of potential and active immunity.

The Untoward Effects of Exercise.—The neuromuscular mechanism becomes adjusted to meet the daily demands made upon it. As long as those daily demands are reasonable and are not greatly varied or increased this mechanism performs its work with ease and comfort. When any new coördination is brought into active play, or when a relatively excessive demand is made on the old coördinations, there result several effects which are more or less disagreeable.

The muscles that have been thus unusually exercised become tender to the touch and painful on active motion. This discomfort may be considerable. It may be temporarily incapacitating. It is probably

due to the local and general toxic influence of tissue wastes and to local mechanical traumatisms.

A well-muscled man who returns to physical exercise after a period of inactivity may enter too actively and abruptly into the performance of his old exercises. Under such circumstances muscle tendons, and even bones, have been broken by the power of the muscular contraction acting on these structures weakened through disuse. The local soreness is usually greater in these cases, because there is a likelihood of more extensive tissue trauma than there is in individuals with weaker muscles, and special care should be taken in these cases to begin with mild exercise and increase the activity gradually.

Physical exercise employed for health purposes need never have any injurious effects. If the prescription is made with intelligent concessions to the previous training, present condition, strength, and organic limitations of the individual, there will be no injurious effects. Physical exercise employed for athletic purposes may very easily have injurious effects. But even then the excessive demands of physical exercise may be without apparent injury to the picked men that undergo the ordeal of athletic training. The scope of this chapter does not include a consideration of exercise in athletics, but a knowledge of the common injuries and undesirable effects of the excessive exercise inseparably associated with modern athletics is of importance. Many practitioners find their younger patients entering into public school and collegiate athletics without reference to their organic capacity for such work. There is a fortunate tendency on the part of these educational institutions, as well as the better class of athletic clubs, to exercise some sort of a medical supervision over the admission of the candidate to athletic training and over his continuance in training. But for obvious financial reasons it is only rare that this institutional supervision is adequate. The amount of time which the examiner can spend on each individual and the number of times he can see any given case under these systems is entirely too small. As a result, we find too frequently that the health of the individual is sacrificed in the interest of athletic success.

The more common injuries of excessive exercise in athletics are: Muscular hypertrophy and shortening, with consequent anatomical asymmetries, such as uneven height of shoulders, forward protrusion of the shoulders, with rounding of upper back, semiflexion of elbows at rest, semiflexed hand, and large chest, with small hips and legs, as in the case of the expert gymnast; excessive cardiac hypertrophy, with dilatation; arteriosclerosis in adults; and inguinal and femoral hernia.

In case of organic weakness the effect of the strain in excessive exercise, particularly in competitive athletics, is often made manifest at the point of weakness. In this way excessive exercise has an untoward effect upon such conditions as chronic endocarditis, chronic myocarditis, chronic pericarditis, established arteriosclerosis, aneurysm, varicose veins, incipient, quiescent, and arrested pulmonary tuberculosis, emphysema, chronic bronchitis, asthma, chronic pleurisy, hernia, chronic or recurrent appendicitis, chronic nephritis, gynecological displacement, spinal Pott's, scoliosis, sacro-iliac disease, hip disease, and flat foot.

Indications for the Administration of Exercise.—Some form of exercise is necessary to individual health at all ages and in all stages of development and under all conditions save those present during the acute attacks, exacerbations, or terminal stages of disease.

Many people secure enough physical exercise in the performance of their day's work to satisfy their physiological needs. Exercise that is accomplished under pleasant, interesting, and recreative conditions is more valuable than that which comes from the routine of daily housework or from the routine of office work. But, though less desirable, such exercise has its physiological influence, and in many cases serves to maintain some degree of health for the individual. There is no such thing as physiological efficiency in the absence of all exercise. Under such circumstances the individual is necessarily bedridden, and suffers structural and functional deterioration which must eventuate in death.

In health the variety and quantity of exercise indicated depends upon the age, sex, habits, physique, and condition of the individual. The babe must have freedom for the kicking, squirming, grasping, and twisting movements that develop his musculature, incite and perfect his larger coördinations, and stimulate his whole organism to normal functional activity. The growing child continues these absolutely essential influences through his play, games, and sports, and secures these physiological benefits more or less completely in spite of the restrictions of the home, the school, and urban life. The mature individual either deliberately plans for exercise or secures it incidentally in the pursuit of his pleasures, his day's work, or both.

If the babe is bound fast, he does not grow. If the child is forced to lead an absolutely sedentary or bedridden life, he does not develop. If the mature human being reduces his exercise to a critical minimum, he is soon without strength or endurance, and is without resistance to disease. Such a babe rarely reaches childhood, and the days of the child and the man are numbered.

In the normal individual some form and amount of exercise is indicated at all ages. The following abnormal conditions are types which indicate special prescriptions of exercise for local and general effects:

1. The poor appetite, indigestion, constipation, dull headache, and bad breath of sedentary life.
2. Weak, flabby muscles.
3. Overweight and underweight.
4. Cardiac and circulatory weakness.
5. Chronic cardiac and circulatory lesions.
6. Undeveloped lung capacity.
7. Chronic pulmonary lesions.
8. Chronic kidney lesions.
9. Gout and rheumatism.
10. Nervous excitement, fatigue, and exhaustion, and the various consequent neurological diseases.
11. Sexual perversion and excesses.
12. Mental diseases.

13. Convalescence from acute disease.

14. Neurological diseases, with approximate or complete loss of function.

15. Chronic joint diseases.

16. Ventral, inguinal, and femoral hernia, bubonocoele, and weak abdominal walls.

17. Unhealed wounds, fractures, sprains, etc.

The Contraindications of Exercise.—Reasonable exercise is never absolutely contraindicated in all its forms save during the acute attacks, exacerbation, or terminal stages of disease. Excessive exercise is always contraindicated, particularly in the presence of any of the various organic conditions and lesions that would invite injury through its influence. The term excessive is relative. Exercise that is mild for one man would be excessive for some other. Exercise that would produce breathlessness, and consequent injury, in one case of pulmonary disease, might be without effect upon the respiratory rhythm of another better trained pulmonary case. Exercise that will send one individual to bed the next day with exquisitely tender muscles, a bad headache, a slight fever, and a concentrated urine will have no apparent effect upon some other better conditioned individual. Exercise which is moderate for the normal individual is usually excessive for patients suffering with various cardiac, circulatory, pulmonary, and nervous diseases.

Excessive exercise which produces a great increase in heart rate and blood pressure is contraindicated in the presence of such conditions as chronic endocarditis, myocarditis, tachycardia, bradycardia, arteriosclerosis and its various complications, thrombosis, aneurysm, varicose veins, Addison's disease, and exophthalmic goitre.

Exercise which is accompanied by a great increase in pulmonary respiratory movement is contraindicated in chronic pulmonary diseases in which there is danger of rupture and pulmonary hemorrhage, or pneumothorax.

The general nervous stimulation and excitement accompanying excessive exercise is injurious to patients suffering with fatigue, chorea, hysteria, neurasthenia, epilepsy, nervous indigestion, exophthalmic goitre, etc.

The burden of the resulting increase in excretory activity contraindicates excessive exercise in such conditions as chronic nephritis, chronic cystitis, asthma, emphysema, chronic bronchitis, and chronic moist skin lesions.

The Administration of Exercise.—The amount and sort of exercise that may be given wisely varies with the age, sex, previous habits of exercise, and the present strength and organic condition of the individual. In any case, the first exercise should be mild. That is to say, there should, as a rule, be none of the muscular soreness, stiffness, and other disagreeable effects that are consequent upon taking too much exercise after a period of inactivity, or that are consequent upon changing abruptly from one line of exercise to another. If the amount of exercise is gradually increased, the capacity of the individual will increase in

proportion, so that the desired physiological effects may be secured without discomfort or accident.

Exercise is better given in the middle of the morning or fairly late in the morning, or in the middle or late part of the afternoon. Exercise immediately after meals interferes with normal digestion. Cannon found that gastric and peristaltic movements ceased when the laboratory animal struggled. I have found, as did Lombard and others, that the power of voluntary muscular contraction is less in the early morning and immediately after meals than at other times of the day. The variation which I secured indicated a period of maximum power roughly between 11 A.M. and 1 P.M., and between 4 and 6 P.M., and a period of minimum power earlier in the morning and early in the afternoon.

Exercise should be taken under comfortable and pleasing surroundings. This is particularly desirable in nervous and impressionable cases. Interest is a *sine qua non* in younger immature persons and a valuable adjuvant in any case. Comfortable clothing, good ventilation, good illumination, and satisfactory heating are necessary for indoor exercise.

Outdoor exercise is better than indoor exercise, other factors being equal.

Exercise should be regular. It should be taken daily. It should in most cases be followed by a bath, preferably a cool bath. The temperature of the bath must, however, be regulated to suit the reaction of the individual case. General massage after exercise is a valuable adjuvant where the nature of the case will permit.

The Varieties of Exercise at the Disposal of the Practitioner.—Exercise may be either passive or active. Under the term "passive exercise" we include those procedures by means of which we secure exercise effects from the manipulation of the muscles without making any demands upon the nervous energy of the individual. These procedures are massage, mechanical vibration, passive motion, and electric excitation. They are of particular value where general nervous, respiratory, vasomotor, or cardiac excitement is contraindicated, and where the condition of the patient makes it unwise or impossible for him to stimulate his muscles voluntarily.

Massage assists in the removal of wastes from the tissues treated by increasing the lymphatic and venous flow. This is a mechanical influence like the squeezing and pumping process described above with reference to the local influence of muscular contraction. This secures a moderate or minimum increase in hormone action and subsequent excretory activity. The mechanical effect of the massage also initiates some degree of vasomotor action, with consequent local vasodilatation and increased blood supply. The final influence of massage, then, is better tissue nourishment, with a minimum effect upon the nerve centres, respiration, cardiac action, circulation, perspiration, and excretion. In addition, massage may be applied without disturbing wounds or other injuries which make ordinary exercise impossible.

Mechanical percussion and vibration have the same general effects as massage, but in certain cases they cannot be administered as intelli-

gently, nor are they as capable of the same degree of adjustment as is massage. On the other hand, mechanical devices like some of the Zander machines have very important special applications.

Pure passive motion has a minimum effect upon conditions in the muscles. These effects are like those of massage, though less in degree. In addition, passive motion has a direct and important effect on joint surfaces, tendon and tendon sheath surfaces, aponeuroses and ligaments, restoring in some chronic joint cases almost the normal amplitude and facility of movement.

Electric excitation, inducing muscular contraction, lies somewhere between massage and active exercise in its physiological influence. Under careful and intelligent supervision, the electric stimulation of voluntary muscles appears to secure the same results in lesser degree and extent that are common to active physical exercise, with this exception—the voluntary nerve centres are not brought into activity. This form of exercise is applicable to those cases in which it is undesirable or impossible for the individual to exercise his motor centres.

Active exercise may include any and every form of movement accomplished by the normal activity of the neuromuscular mechanism. We have formal exercise without apparatus; exercise in which the contraction of one muscle group is resisted by the contraction of its antagonistic group; and exercise in which one individual, the operator, resists formal movements performed by another individual, the patient.

We have exercise with light apparatus (see Plates VI to X, inclusive), exercise with heavy apparatus, exercise in which the individual moves the apparatus about in a formal way, exercise in which the apparatus is fixed and the individual moves himself, with the apparatus as his support. These are varieties of exercise characteristic of the gymnasium.

And then we have exercises through games, sports, and play.

Formal exercise without apparatus or with light apparatus is of value, because the exercise may, within certain limits, be localized; and the severity of the exercise may be regulated to a minimum. Untoward respiratory, cardiac, vasomotor, nervous, and excretory influences may be reduced or practically eliminated. The amount of exercise here, as elsewhere, depends upon the rhythm of movement and the resistance to be overcome.

Formal exercise with heavy apparatus and exercise in which the body is moved about a fixed piece of apparatus is more likely to be interesting to the capable individual than are the formal lighter exercises. These heavy exercises are likely to produce anatomical asymmetries. They give large opportunity for the strain of weak organs, because of the increased blood pressure and the increased intra-abdominal and intra-thoracic pressures that arise with the great effort common to such work. Such exercises very greatly increase the blood pressure and are contraindicated in all cases of cardiac, pulmonary, and vascular weakness, and in the presence of hernia, incipient, present, or probable (as in the presence of a separation of the recti abdomini, weak abdominal scar, and large inguinal ring).

Games, sports, and play are the most satisfactory forms of physical exercise for the normal younger individual. Such activities usually take place in the open and are often attractive and interesting. The demands which such forms of exercise make upon the structural and functional status of the individual vary within large limits. Croquet goes well with arteriosclerosis, but hand-ball would be dangerous. On the other hand, the reaction of the individual to the physiological demands of any one of these forms of exercise depends upon his physique, his training, and his condition. As I have stated elsewhere, exercise that is mild for one patient may be severe for another.

In advising any of the above forms of exercise, passive or active, the practitioner will be guided by the object for which he is prescribing; the structural and functional effects of the sort and quality of exercise which he prescribes; and the age, sex, previous experience, physique and present condition of his patient.

The following calisthenic and chest-weight exercises are offered as types of drills which can be utilized for light, moderate, or heavy work. If the rhythm of movement is very slow, if no hand apparatus, or if lighter weights are used, if the heavier movements are eliminated, and if periods of rest are entered at regular intervals, the physician may secure a very mild type of exercise. If, on the other hand, the rhythm is made rapid, if dumb-bells are used for some of the movements, and if the number of counts to each movement is increased, the patient may be given a severe exercise.

Calisthenic Exercises.—**Directions for Form and Execution.**—Position: Heels about a foot apart, toes directly forward, arms in side hang, chest up, chin drawn down and back.

Execution: Continue each movement for four, eight, sixteen, or more counts. Rhythm from one to three movements per second. Slower rhythm, one to three seconds between each movement, with frequent periods of rest when it is desired to reduce the excitatory and excretory effects to a minimum.

Movements.—1. Inhale, raising arms through side horizontal to vertical position, then arms to side hang; exhale. Repeat.

2. Inhale, raising arms to vertical through front horizontal; arms to side hang through side horizontal; exhale.

3. Inhale, raising arms to front horizontal, then to side horizontal; arms to side hang; exhale.

4. Open and close hands.

(a) Repeat, arms in side horizontal.

(b) In front horizontal.

(c) In vertical.

(d) In side horizontal.

(e) Position.

5. Arms in side hang. (a) Flex forearms, bringing fists to shoulders. (b) Repeat in the four positions, *i. e.*, arms in side, horizontal, front horizontal, side horizontal, and vertical.

6. From position with arms vertical.

(a) Arm circles inward, crossing arms in front of body (full arm circumduction).

(b) Repeat, making the movements in the opposite direction.

7. (a) Rotate full arm.

(b) Repeat in the four-arm positions.

Position: Legs well apart; hands on hips, thumbs pointing backward.

8. Bend trunk to the right (knees and hips firm; chest, neck, and head in good position); then left.

9. Trunk bend forward and return to erect position (position as in No. 8, bending at hips). Repeat.

10. Alternate No. 8 and No. 9.

11. Rotate trunk to the right; then left.

12. Hands between ankles; with body bend forward (slight bend at knees); arms through front horizontal to vertical; body erect.

13. Same; arms through front horizontal to side horizontal.

14. Same, to front horizontal; half turn of body to the right; right knee bent; arms reaching far to the right; alternate with same movement to the left. Position: heels and toes about twelve inches apart; hands on hips.

15. Squat and return (flex and extend thighs on legs).

16. Spring from toes (knees and hips straight).

17. Spring from toes, alternating position of thighs from abduction to adduction.

18. Standing run, raise knees high in front.

Position: Body extended on floor with the weight sustained by the toes and arms; knees, hips, back, and neck straight.

19. Spread legs and return.

20. Flex and extend arms (lowering and raising the body).

21. Flex hips and knees, bringing feet between hands; rise to erect position (in good form); return through same position to "front rest on floor."

Position: Supine, arms at side or clasped back of head.

22. Flex right knee, bringing heel to buttock.

(a) Repeat left.

(b) Alternate.

(c) Combine.

23. Flex right thigh on trunk, knee and ankle straight.

(a) Repeat left.

(b) Alternate.

(c) Combine.

24. Spread legs and return (abduct and adduct thighs).

25. Raise head from floor.

26. Raise thorax from floor, resting weight on occiput and buttocks.

27. Raise head and chest from floor; neck straight.

28. Raise trunk to sitting position and return.

29. Raise body, resting weight on heels and occiput.

30. Arms at side, inhale while bringing arms through lateral extended position to cephalad extended position (remember the body is supine). Return arms to sides; exhale.

31. Inhale, bringing arms through front extended position to cephalad extended position; return arms through lateral extended position to side; exhale.

32. Inhale, bringing arms to front extended position and to lateral extended position. Return directly to side position; exhale.

Type Exercises for Chest Weights.—Position: Face machine, feet parallel and about twelve inches apart, toes directly forward, arms hanging at sides, chest up, chin drawn back and down.

Execution: Rhythm, one or two movements a second, and larger weights for greater physiological effects. One or two seconds to a movement, and lighter weights for minimum effects. Four, eight, sixteen, or more movements to each exercise.

Movements.—1. Arms to front horizontal and return.

2. Arms to front horizontal, to side horizontal, to front horizontal, to side hang.

3. Arms to front horizontal, side horizontal, front horizontal, vertical, and return; through same series.

4. Right arm vertical; alternate left and right to vertical.

5. Arms to vertical and return.

6. Arms front horizontal, flex to shoulders, front horizontals, and down. Legs well apart.

7. Hands between ankles; swing arms to front horizontal; half turn of trunk to right; slight bend of right knee.

8. Same, left.

9. Alternate 7 and 8. Feet as before.

10. Arms vertical; step right leg far to the right; hands to floor in front of right foot; return to stand, with arms in vertical, arms to side.

11. Repeat on left.

12. Alternate right and left. Face away from machine.

13. Arms to front horizontals, side horizontals, front horizontals, and down.

14. Arms to front horizontals, side horizontals, front horizontals, vertical; return through same series to side hang.

15. Alternate right and left, arms to vertical.

16. Arms in front horizontal, flex to shoulders.

CHEST WEIGHT EXERCISES.

FIG. 4

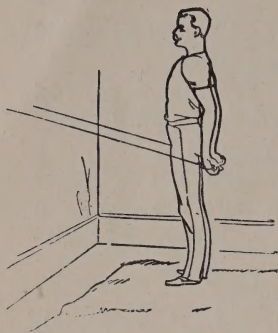


FIG. 5

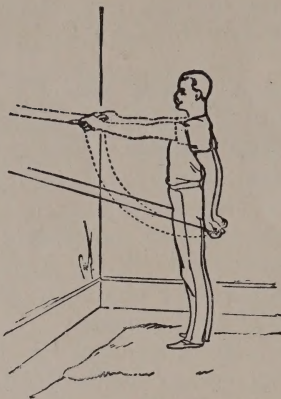


FIG. 6

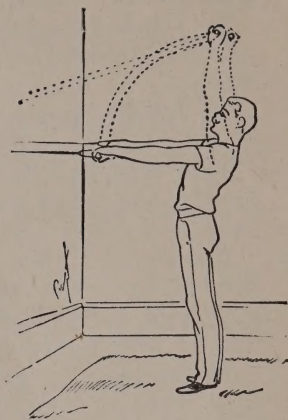


FIG. 7

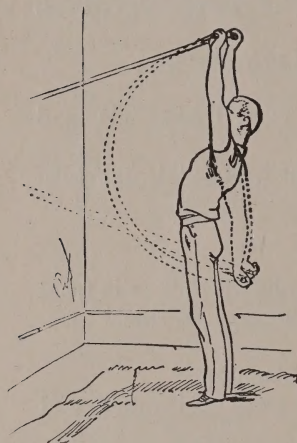


FIG. 8

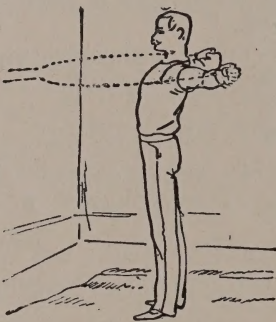


FIG. 9

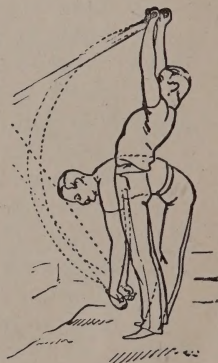


FIG. 10

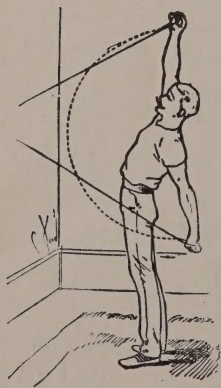


FIG. 11

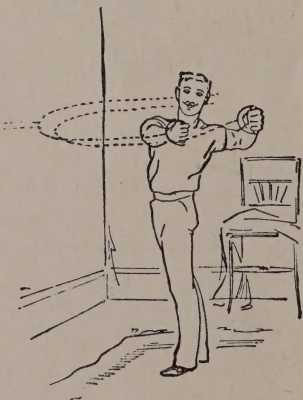


FIG. 12



FIG. 13

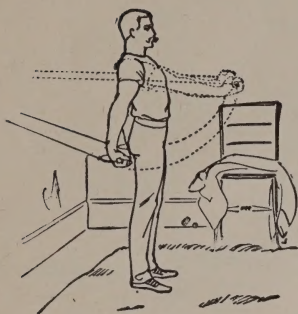


FIG. 14



FIG. 15

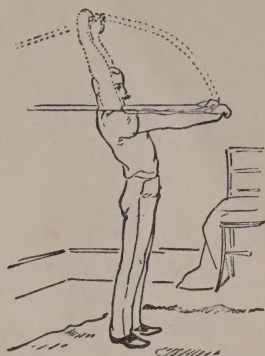


FIG. 16

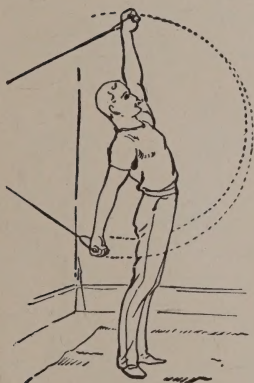


FIG. 17

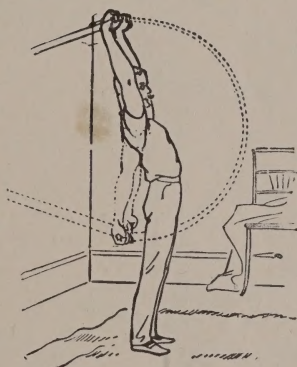


FIG. 18

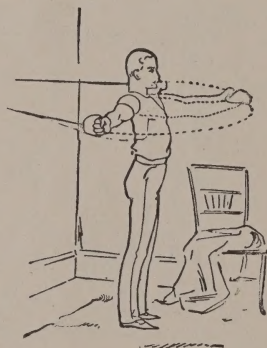


FIG. 19

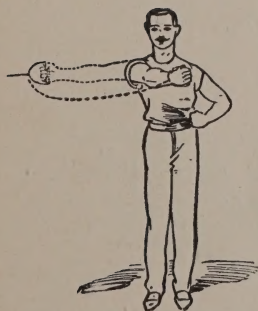


FIG. 20

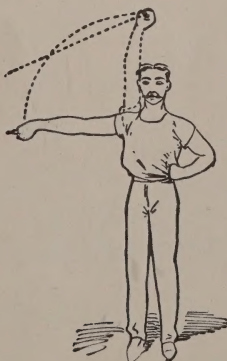


FIG. 21

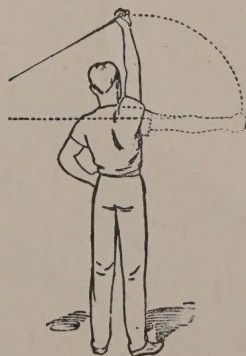


FIG. 22

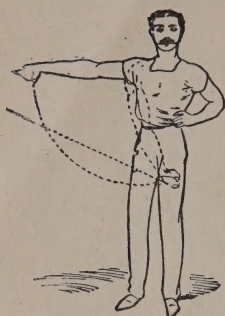


FIG. 23

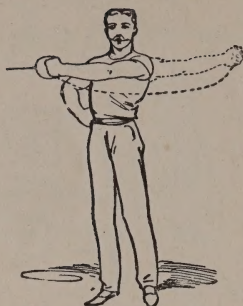


FIG. 24

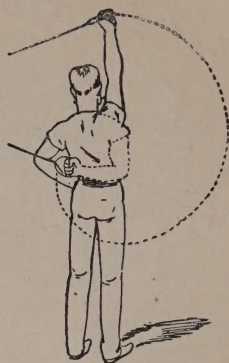


FIG. 25

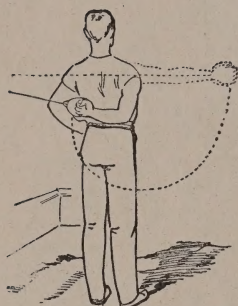


FIG. 26

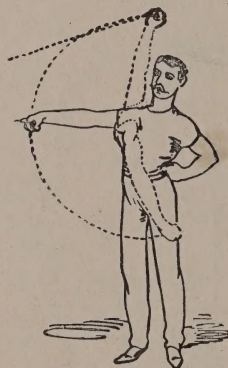


FIG. 27

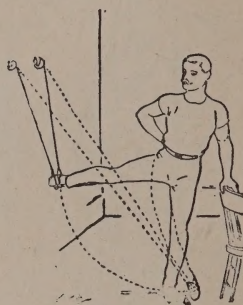


FIG. 28



FIG. 29

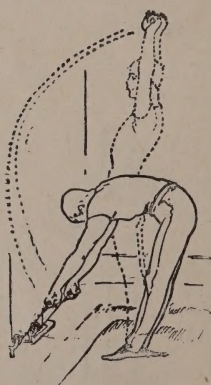


FIG. 30



FIG. 31



FIG. 32

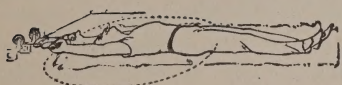


FIG. 33



FIG. 34

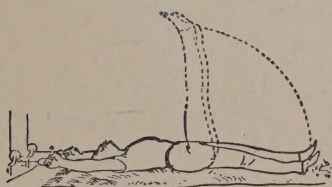


FIG. 35

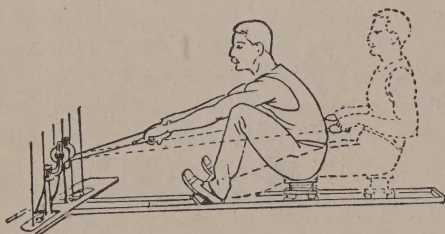
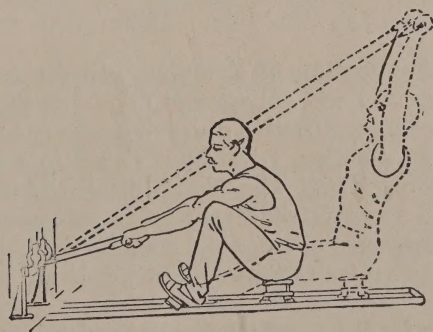


FIG. 36



Rowing machine exercises.

FIG. 37

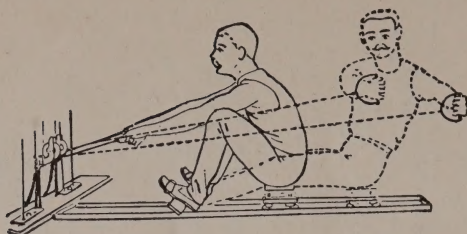
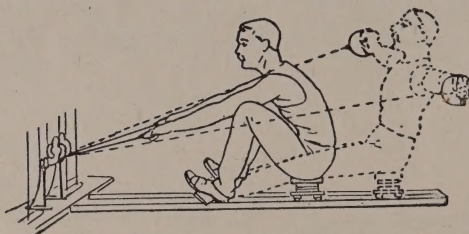
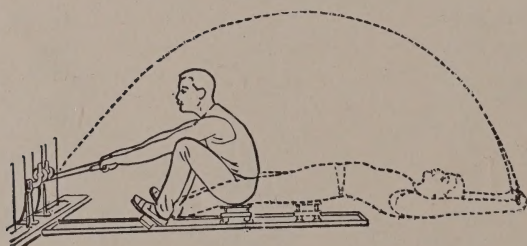


FIG. 38



Rowing machine exercises.

FIG. 39



Rowing machine exercises.

NOTE.—I am indebted to the Narragansett Machine Company for illustrations Nos. 4 to 39, inclusive.

The General Application of Exercise.—In discussing the general application of exercise I will not attempt to go into the details of treatment in any given disease. Such a discussion belongs to the therapeutics of that disease. In addition, I will limit myself to a discussion of the general principles involved. The special details belong to the special practitioner, as in the reëstablishment of coördinations in locomotor ataxia, or in the treatment of structural scoliosis through exercise. The limitations of this chapter and its subject preclude the exploitation of such details.

General Exercise for the Normal Individual.—Every well-ordered individual policy of personal health control must include regular habits of

physical exercise. Every actively, aggressively, and successfully healthy individual has consciously or unconsciously satisfied his physiological demand for exercise. But no personal health policy is complete or successful which does not include several other essential health habits. We have seen that exercise is intimately and inseparably associated with rest, nourishment, excretion, and physiological protection. These considerations must inevitably enter into every intelligent plan for the utilization of exercise as a health procedure. And, on the average, every normal man that exercises wisely, rests wisely, eats, drinks, and breathes intelligently, takes care of his excretions, and reasonably avoids the agents and carriers of disease, will develop and maintain a high degree of tissue health and consequent physiological efficiency. Such an individual will be less easily infected by our common communicable diseases, and, once infected, he will more easily recover. His active and potential immunity will be more highly developed.

Exercise, for the normal individual, should be taken daily. Greater benefit will be secured through exercise that causes moderate respiratory, cardiac, and circulatory excitement with sweating, but very satisfactory results follow exercise which falls short of such effects. Exercise should be followed by a bath, preferably cool, and a rub-down. A very satisfactory effect may be obtained by following the bath with a brisk rub with a coarse towel.

The normal individual may select his exercise from a variety of sources with special reference to his individual needs and limitations. He may use formal gymnastics, with or without apparatus, chest weights, heavy gymnastic apparatus, recreative gardening, wood-working, walking, billiards, croquet, quoits, mountain climbing, hunting, fishing, rowing, swimming, bicycling, horseback riding, tennis, golf, hand-ball, the punching bags, boxing, fencing, skating, skiing, and other games and sports.

The Application of Exercise in Abnormal Cases.—1. *Sedentary Habits.*—The accompaniments of sedentary habits are commonly indigestion, constipation, acne, lack of appetite, headache, bad breath, and mental dulness, with often obesity. The nervous type presents varied degrees of indigestion, constipation, insomnia, headache, irritability, and more or less underweight. The two types are not necessarily distinct.

In such cases the sedentary habit and its undesirable and more or less dangerous accompaniments and sequelæ may be “cured” by instituting regular habits of exercise and establishing wise habits of rest, nourishment, excretion, and bathing. Such patients should undertake mild exercise at first. Otherwise they will suffer from muscle soreness. They may begin with light, formal gymnastics, easy walking, chest weights, croquet, quoits, billiards, and golf. Massage will be of benefit at all stages. As the strength and condition of the patient improve, he should increase the amount of exercise taken, either by increasing the vigor with which he performs those already undertaken or by adopting new and more vigorous exercises. Within certain limitations it may be

truly said that one gets out of exercise what he puts into it. Bowling, tennis, fencing, boxing, bag-punching, horseback-riding, hand-ball, squash, and other heavier games and exercises may be prescribed when the individual becomes physically fit to meet the demands which they make upon his muscles, heart, lungs, and circulation.

2. *Convalescence*.—Convalescence may be hastened by the wise administration of exercise. During the period in which the patient is too weak to undertake voluntarily even the mildest form of physical exercise he may be treated by manipulation (passive movements) and massage. This treatment may accompany the routine sponging usually prescribed at this time. The transition from the recumbent to the sitting position in bed may be accomplished gradually by adding pillows for the higher support of the head and trunk. As soon as the sitting position may be sustained for several hours without untoward nervous, respiratory, cardiac, or circulatory disturbance the patient may be carried to a chair and possibly some attempt made to stand. Later, a walk from the chair to the bed may be added, and the physical demands gradually increased from day to day as the strength and functional reaction of the patient indicates its practicality. The success of such treatment will depend absolutely upon the success with which the rest, nourishment, excretion, and physiological protection of the patient is handled. Outdoor exercise should be taken as soon as practicable. The patient may at first sit on the porch, in the yard, or on the roof. Later, the vibratory effects of the carriage, trolley car, or automobile may be of benefit. The patient gradually gains strength and is able to walk increasing distances with firmer, more normal, and more active step. After a time, when his strength permits, he may undertake mild forms of gymnastics; then such games as croquet and quoits, and, later, golf. Each period of exercise should be followed by a period of rest, and the practitioner should carefully note the immediate effect of the exercise taken upon the heart, circulation, and respiration. This attention in the beginning must be constant and the functional indications faithfully respected. Overdoses of exercise will produce disproportionate and persistent cardiac, circulatory, and respiratory excitement. Such mistakes may lead to general fatigue, collapse, organic complications, and prolonged convalescence.

3. *Conditions in which Rapid Pulse or Increased Blood Pressure are Contraindicated* (e. g., *Tachycardia, Bradycardia, Chronic Endocarditis, Chronic Myocarditis, Chronic Pericarditis, Quiescent Aneurysm, Varices, Arteriosclerosis, Chronic Nephritis, Addison's Disease*).—The various pathological conditions in which increased heart rate and blood pressure are likely to be injurious indicate habits of exercise in which there is no effort and in which the rhythm of movement is comparatively slow and the mechanical work done by any given single movement comparatively small. In all these pathological conditions the aim is to secure as much general and local physiological benefit as is possible without injury to weak organs. The physician will take into consideration the degree of local or general organic weakness, and the age, sex, and nervous

irritability of the individual; his previous training, physique, and present condition, and gauge his prescription according to its effect upon heart rate, blood pressure, and respiratory rhythm. During the last fifteen years I have had opportunity to observe a number of these cases in which it was ultimately possible to secure a half or three-quarters of an hour of systematic exercise with no general increase in blood pressure and with a cardiac acceleration of only three or four beats to the minute. In these cases I have employed free-hand exercises, light dumb-bells, chest weights, and walking. The rhythm must be very slow, and in many cases the mechanical work done insignificant. The patient must exercise without effort, always breathing freely, naturally, and quietly. Frequent short periods of rest interpolated at intervals during the exercise may be necessary in severe cases. Stronger patients may do well with croquet, quoits, and golf. Massage is always valuable. There is a general tendency to underestimate the amount of exercise which can be done by individuals suffering with these lesions. This is particularly true of valvular lesions of the heart. General physiological efficiency, health, and resistance to disease are sacrificed out of overrespect for these weaknesses. Each and all of these conditions are compatible with some degree of exercise. The amount and variety that can be borne with safety in any individual case must be determined by the physician in charge, but in no case should exercise be totally neglected unless contraindicated by acute exacerbations, complications, or sequels of the chronic affection. As the treatment progresses it is regularly possible, within limitations, to increase the amount of exercise without undesirable organic disturbances.

4. *In Chlorosis and Anemia and Some Allied Pathological Conditions Characterized by a Subnormal Amount of Hemoglobin or a Numerical Reduction in Erythrocytes.*—The oxygen-carrying capacity of the blood is limited. For this reason the patient should not undertake any exercise that will increase the tissue respiration. Massage, passive motion, vibratory exercise, and very mild active exercise will assist in the removal of tissue wastes, favor metabolism, without respiratory excitation, and possibly effect desirable hormone action.

5. *Conditions Contraindicating Great Increase in Carbon Dioxide Elimination (e. g., Chronic Bronchitis, Asthma, Emphysema, Chronic Pneumonia, from Any Cause).*—These diseased conditions are frequently associated with a considerable reduction in the alveolar surface areas for respiratory exchange. Under such conditions it is not advisable to prescribe exercise which will increase the need for carbon dioxide excretion beyond the capacity of the alveolar walls. The amount of exercise that may be borne may be increased by training. Exercises with slow rhythm and involving but little mechanical work, and exercises in which only a limited number of muscle groups participate, are accompanied by slight respiratory excitement. These exercises are practically the same as those advised in cases where increased cardiac and circulatory excitement are contraindicated.

It has been my experience that these cases are able, after careful train-

ing, to support a relatively large amount of exercise without undesirable physiological excitement.

6. *Conditions Contraindicating Increased Intrathoracic Pressure (e.g., Pulmonary Tuberculosis and Other Chronic Diseases which Weaken the Bronchial and Alveolar Walls).*—The presence of weakened alveolar or bronchial walls, with the consequent possibility of rupture and pulmonary hemorrhage or pneumothorax, contraindicates any exercise that may increase the intrathoracic pressure. This contraindication would include deep, labored breathing and exercises with effort. In the presence of such conditions all exercise should be accomplished with easy, free, effortless breathing and without increase in respiratory rate or blood pressure. Massage, passive movements, and mild active exercise, with slow rhythm and a minimum of mechanical work, are indicated. If the exercise is carefully undertaken there will be no untoward result, and the local pulmonary and the general physiological efficiency of the patient will be increased.

7. *Conditions which Contraindicate Increased Intra-abdominal Pressure (e.g., Herniæ, Bubonocoele, Diastasis Recti, Scar Weakness in Abdominal Wall).*—There is a variety of conditions in which increased intra-abdominal pressure is contraindicated. All exercise that is accomplished with an effort—that is, by holding the breath and simultaneous contraction of the abdominal musculature—will exert an internal pressure upon the abdominal parietes. Unless care is taken the simplest muscular acts may be accompanied by effort. These patients should be taught to exercise without holding the breath. All of their movements should be accomplished with easy, free, natural breathing. A considerable degree of respiratory activity may be present, with no undesirable effect upon the intra-abdominal pressure. With this precaution in mind, the physician may prescribe any exercise which the condition and circumstances of the patient indicates.

8. *Conditions which Contraindicate Increased Demand upon the Excretory Functions of the Kidneys; Chronic Nephritis.*—Exercise must be carefully regulated in the presence of an impairment of the functional activity of the kidneys. There is some reason for assuming that exercise excesses which are accompanied by the appearance in the urine of albumin, with or without blood and casts, are ultimately productive of serious pathological changes in the normal kidney. In the diseased kidney all exercise is contraindicated which throws an additional burden upon its excretory function. Under such conditions, mild exercise, with only slight cardiac, circulatory, and respiratory excitement, are indicated. The prescription of exercise may be checked up by urinary analysis. There should be no attendant consequential increase in pathological findings. Under some circumstances an increase in perspiratory activity with a consequent concentration of the urine, is the penalty for overexertion.

The high blood pressure, cardiac and valvular changes, associated with chronic nephritis, are also contraindications for excessive exercise.

For obvious reasons the plan of exercise suggested for chronic cardiac conditions is equally applicable here.

9. *Constitutional Diseases which are Characterized by Intervals of Comparative Health* (e. g., Gout, Diabetes, Chronic Rheumatism).—The various chronic constitutional affections which, in their intervals of quiescence, do not greatly limit the activity of the individual, derive a great deal of benefit from regular systematic exercise. Such cases are to be treated as normal individuals in so far as their general or special organic condition will permit.

10. *Conditions in which Nervous Excitement is Contraindicated* (e. g., Nervous Fatigue, General Debility, Neurasthenia, Hysteria, Chorea, Epilepsy, Paralysis Agitans, and General Paresis).—Those conditions in which general nervous excitement is contraindicated are best handled with passive exercise, and later with quiet, formal, moderately slow exercises, in which the effort, mental attention, and mechanical work is at a minimum. Such cases may be treated along the same lines as those suggested for general convalescence, the prescription of exercise being at all times adjusted to fit in with the other necessary lines of treatment indicated. On the other hand there are some of these cases in which it is desirable to engage the interest and attention of the patient, so that his mind may be relieved of the nervous excitement consequent upon his domestic, business, or social affairs. In these cases, other things being equal, recreative games, sports, and plays are effective. Croquet, quoits, walking, golf, bowling, horseback-riding, bicycling, tennis, hand-ball, hunting, fishing, target-shooting, archery, and canoeing may be indicated in special instances.

11. *Neurological Conditions Characterized by Approximate or Complete Loss of Function, Paralysis, Atrophy, or Contracture* (e. g., Locomotor Ataxia, General Paresis, Progressive Muscular Atrophy, Spastic Paralysis, Anterior Poliomyelitis (Convalescent), Diffuse and Focal Lesions of the Brain and Cord, Diseases of the Peripheral Nerves (Neuritis), General and Functional Diseases).—Those neurological conditions that are characterized by loss of muscular function and impairment of muscular nutrition are benefited by the passive exercise of the affected muscles, and in appropriate cases by the educational exercise of nearly allied muscle groups. Passive exercise, through massage, passive motion, and electricity, may serve to delay muscular atrophy through its influence upon local metabolism. New coördinations approximating the utility of those lost may be established, to a limited extent, through the patient exercise of muscles that are still capable of functional activity. It would appear, too, that in some cases at least the careful exercise of the affected muscle group through the medium of a few nerve filaments not destroyed by disease or injury has led to the restoration of a considerable degree of function through the new nerve path.

12. *Mental Diseases*.—The health habits of mental cases need careful supervision. The same general principles operate in their interest as they do in the interest of the normal individual. The same indications and contraindications for exercise present themselves. The practitioner

with a mental case on his hands will invariably find that his patient does better while submitting himself to an intelligent policy of personal health control in which regular systematic exercise figures conspicuously.

In institutional life these patients often do well in group games, sports, and play. Dancing is one of the commonest and most effective exercises in hospitals for the insane.

13. *Bone and Convalescent and Chronic Joint Conditions Indicating Exercise for its Influence upon Local Nourishment, Anatomical Relationship, and Motility* (e. g., *Fractures, Dislocations, Subluxations, Ankyloses, Chronic Arthritis, Faulty Attitudes, Scoliosis, Weak Arches, Flat Feet*).—Early massage and passive motion materially assist in the convalescence of fractures, dislocations, and subluxations, through their beneficial influence upon local nourishment and on arthritic mobility. Through such treatment the injured areas may be given a larger supply of arterial blood and therefore a greater amount of available tissue food. In addition, the improved venous and lymphatic drainage serves to remove more rapidly the products of local injury. Passive motion in these cases may prevent deposits in and about joint surfaces, tendons, and ligaments immobilized for purposes of treatment, which may prolong convalescence or eventuate in stiff joints or complete ankylosis.

Arthritic surfaces, ankylosed either as a result of prolonged immobilization during treatment or as a result of some form of arthritis, may in many cases be restored to a considerable degree of efficiency through forced, graded extension, passive motion, and mechanical vibration. The Zander apparatus is particularly effective in some of these cases.

Anatomical asymmetries due to or accompanied by the stretching of weak muscles may be treated by exercise which will strengthen and therefore shorten the weak and stretched muscles. Such treatment is valueless unless conscientiously carried out for a considerable period of time. Furthermore, such exercise is without effect in removing asymmetries consequent upon bony abnormality or fixed bony asymmetry. Under such conditions, if these exercises can ever be of local corrective value, it can only be after removal of the fixed bony cause.

As a rule, in simple functional scoliosis the asymmetry may be corrected by general symmetrical exercises of the trunk. In such cases systematic exercise will secure a general muscular, ligamentous, and connective-tissue strengthening, with a corresponding improvement in functional activity. The supporting and locomotor tissues of the trunk will then perform their duties more evenly and successfully.

The treatment of structural scoliosis is within the special province of the orthopedic surgeon.

Faulty attitudes are largely the result of habit, associated with a weak musculature. If the faulty attitude has not become fixed through muscular, connective tissue, and bony change, it can be corrected through persistent general exercise in correct position. Those cases in which the anatomical relationship has become rather rigidly and firmly fixed require special attention.

Weak arches are benefited by exercises in which the muscles that pro-

duce plantar flexion and inversion of the feet are strengthened and shortened. Such cases should be taught to walk with the feet directly forward, or "toeing in." They should exercise more or less while supporting the weight of the body on the outer side of the plantar surface of the foot. Movements of plantar flexion and of ankle circumduction with the plantar surface of the foot facing the median line (pedal inversion) are useful. The muscular exercise secured through attempted plantar flexion while walking, and through pedal inversion while walking, is of value. In addition, general exercise with improved general condition will be of local benefit.

As in structural scoliosis and rigid faulty attitudes, flat foot comes under the province of the specialist.

